The Sodium Spectrum

Introduction

No chemistry class is complete without the spectacular demonstration of alkali metals reacting with water. The Sodium Spectrum is a novel variation that is much safer to perform than the standard sodium demonstration of simply dropping a small piece of alkali metal into a beaker of water. It also demonstrates the colourful spectrum of colours possible with acid–base indicators. In the Teaching Chemistry video, John Little used long glass stirring rods (one for each cylinder) after adding indicator (before adding mineral oil) and again after sodium reacts creating color change.

Concepts

- Alkali metals—reaction with water
- Density
- Acid–base indicators

Materials

Sodium metal, Na, 5 small pieces
Mineral oil, 1000 mL
Phenolphthalein, 0.5% solution, 1 mL
Thymolphthalein, 0.5% solution, 1 mL
m-Nitrophenol, 1.0% solution, 1 mL
Water, 1000 mL
Glass cylinders, approximately 500-mL, 5
Stirring rods (optional)
Support stands and clamps (optional), 5

Safety Precautions

Sodium metal is a flammable, corrosive solid; dangerous when exposed to heat or flame; dangerous by reaction with moist air, water, or any oxidizer. Purchasing pre-cut pieces for performing this demo greatly reduces the potential hazard of the material. Sodium reacts with water to produce flammable hydrogen gas and a solution of corrosive sodium hydroxide. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Clamp the hydrometer cylinders or large graduated cylinders to support stands for stability (optional).
2. Add about 200 mL of water to each cylinder.
3. Add 8 drops of phenolphthalein and 2 drops of *m*-nitrophenol to the first cylinder (red).
4. Add 10–15 drops of *m*-nitrophenol to the second cylinder (yellow).
5. Add 2 drops of thymolphthalein and 12 drops of *m*-nitrophenol to the third cylinder (green).
6. Add 10 drops of thymolphthalein to the fourth cylinder (blue).
7. Add 8 drops of phenolphthalein and 2 drops of thymolphthalein to the fifth cylinder (violet).
8. Add 200 mL of mineral oil to each cylinder to form a layer above the water.

Procedure

1. Drop a piece of sodium, about the size of a small kernel of corn, into each cylinder and observe the reaction.
2. Wait about 2–3 minutes for all five indicator colours to fully develop as the aqueous solutions become basic.

Disposal

It is recommended that you consult your local school board and/or municipal regulations for proper disposal methods that may apply before proceeding.

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Tips

- This is a very safe method for demonstrating the reactivity of sodium metal with water. Do not attempt this demonstration with potassium.
- Make sure all the cylinders are stable and secure so they cannot tip over. Glass 500-mL graduated cylinders or large hydrometer cylinders work very well.
- This demonstration works well with very small pieces of sodium. Flinn sells a bottle with 5 small pieces of sodium metal that can actually be cut in half for this demonstration.
- Make sure the mineral oil is dry. If it is wet, the sodium may react more violently and form a less dense piece that will float on top of the mineral oil layer.
- A video of this demonstration, *The Sodium Spectrum*, presented by John Little, is available online for viewing as part of the Flinn Scientific "Best Practices for Teaching Chemistry" Teacher Resource videos. The demonstration is part of the Acids and Bases videos.

Discussion

When added to the cylinder, sodium will sink until it reaches the interface between the two layers, at which time it reacts with water, forming hydrogen gas and the base, NaOH:

$$2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq)$$

The evolution of hydrogen gas is evident, and hydrogen bubbles adhering to the sodium will carry it into the hydrocarbon layer, temporarily stopping the reaction. The amount of hydrogen and heat evolved is kept under control by this swimming behaviour, making this demonstration quite safe. The piece of sodium repeatedly dives down to the water-hydrocarbon interface, reacts, then "swims" back up into the hydrocarbon layer until the reaction is complete. During the reaction, the piece of sodium is largely devoid of corrosion, allowing the students to view its gray, metallic appearance.

Density is an important physical property that can be used to separate materials or control reactions. Sodium has a density of 0.97 g/mL and sits at the interface of water and a hydrocarbon. The interface between two immiscible solvents is an effective site for controlling chemical reactions. Many industrial processes use this concept to react aqueous salts with nonpolar hydrocarbons.

Acknowledgment

Special thanks to John Little, retired chemistry teacher, CA, for bringing this demonstration to our attention.

Materials for *The Sodium Spectrum* are available from Flinn Scientific Canada Inc.

Catalogue No.	Description
SJ0034	Sodium Lumps, 100 g
MJ0064	Mineral Oil, Light, 500 mL
PJ0020	Phenolphthalein Solution, 1%, 500 mL
AP8599	Hydrometer Cylinder, 600-mL
TJ0079	Thymolphthalein Indicator Solution, 100 mL
AP8150	Stirring Rods

Consult www.flinnsci.ca or your *Flinn Scientific Canada Catalogue/Reference Manual* for current prices.